

Dissertation On

**ROLE OF MRI IN THE EVALUATION OF PELVIC
FLOOR INTEGRITY IN STRESS INCONTINENT
PATIENTS**

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BONAFIDE CERTIFICATE

This is to certify that the study entitled “**ROLE OF MRI IN THE EVALUATION OF PELVIC FLOOR INTEGRITY IN STRESS INCONTINENT PATIENTS**” is the bonafide work done by Dr.V. SUJATHA, M.D., P.G. at the Barnard Institute of Radiology, Madras Medical College, Chennai.

This dissertation submitted to Dr.MGR Medical University is in partial fulfillment of the University regulations for the award of M.D. Degree in Radiodiagnosis.

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INTRODUCTION

MR imaging of the pelvic floor was first reported by Yang et al in 1991 using T1-weighted gradient-echo sequences. Because of the relatively long acquisition times, dynamic imaging was only feasible in cooperative patients. The development of stronger, faster gradients and ultra fast T2-weighted pulse sequences with acquisition time under 1 sec now permits dynamic evaluation of the pelvic compartments at maximal strain. By enhancing tissue differentiation, the heavily T2-weighted images also obviate the administration of contrast medium.

A possible objection to our methodology is that the images were acquired in a physiologically inappropriate supine position. Open-configuration MR imaging systems permit imaging in the sitting position, simulating the conditions most often associated with urinary leakage by combining the effect of gravity with the increased intra abdominal pressure caused by the Valsalva's maneuver and the damaged pelvic floor.

Pelvic organ prolapse is abnormal symptomatic displacement of the pelvic organs from their normal anatomic position and is part of the

spectrum of abnormalities in pelvic floor dysfunction. This condition primarily affects women and can be debilitating as well as embarrassing.

Patients can have pain, pressure, urinary and fecal incontinence, constipation, urinary retention, and defecatory dysfunction. Frank prolapse of pelvic tissues through the vagina can also occur. Pelvic floor dysfunction has a significant impact on society. Organ prolapse has been demonstrated at physical examination in up to 16% of perimenopausal women.

Pelvic organ prolapse can include loss of support and herniation of the urethra, bladder, vaginal vault, cervix, small bowel, sigmoid colon, or rectum. Diagnosis is made primarily on the basis of findings at pelvic physical examination. If the findings are equivocal or do not explain the patient's symptoms, imaging may be performed. Fluoroscopy, ultrasonography (US), and magnetic resonance (MR) imaging can demonstrate prolapse.

Advantages of MR imaging include lack of ionizing radiation, depiction of the soft tissues of the pelvis, and multiplanar imaging capability.

AIM OF THE STUDY

The aim of study was to evaluate the role of magnetic resonance imaging in prolapse and stress incontinence with regard to

1. Pelvic floor integrity
2. Urethra

REVIEW OF LITERATURE

In 1991, MR imaging of the pelvic floor was first reported by Yang et al using T1-weighted gradient-echo sequences. Because of the relatively long acquisition times, dynamic imaging was only feasible in cooperative patients.

In 2000, J.R.Fielding et al⁶² conducted a study on ten healthy nulliparous female volunteers who underwent T2-weighted MR imaging of the pelvis. Three-dimensional color-coded models of the pelvic bones and organs and the three major components of the levator ani were created. Source images were used to measure muscle width and signal intensity and to identify ligamentous structures. In all volunteers, the signal intensity of the puborectalis exceeded that of the obturator externus. The average volume of the levator ani was 46.6 ml, the average posterior urethrovesical angle was 143.5° and the average width of the levator hiatus was 41.7 mm .

In 2000, Kelvin²⁶, compared dynamic MR imaging with fluoroscopic cystocolpoproctography for the detection and measurement of prolapse of pelvic organs in 10 patients. They concluded that MR imaging & fluroscopic cystocolpoproctography show similar detection

rates for prolapse of pelvic organs. Although dynamic MR imaging underestimates the extent of cystoceles and enteroceles, it has the advantage of revealing all pelvic organs and the pelvic floor musculature in a multiplanar cine-loop presentation.

In 2000, Elena Rociou et al⁴² performed a study in 100 healthy volunteers (50 women, 50 men). The essential anatomic structures were evaluated, and various patterns in men and women were recorded. The thickness of the anal sphincter muscles and the length of the anal canal were measured, and age- and sex-related correlations were studied. Sex-related differences included a significantly shorter external sphincter in women than in men both laterally (mean, 27.1 mm \pm 5.4 vs 28.6 mm \pm 4.3; $P < .05$) and anteriorly (mean, 14.0 mm \pm 3.0 vs 27.0 mm \pm 53.0; $P < .051$). Age-related variations included a significant decrease in the thickness of the external sphincter in men ($P < .01$).

In 2001, unterweger et al²⁴ studied thirty continent women and divided into three equal groups (nulliparous, previous cesarean delivery, previous vaginal delivery) and compared with 10 women with stress-incontinence. MR imaging of the pelvic floor at rest and on maximal strain was performed. Cervical descent was greater in incontinent versus nulliparous women. Bladder floor descent was greater in the continent

vaginal delivery group than in continent cesarean delivery control patients. In patients with stress incontinence, symptoms did not correlate with amplitude of descent.

In 2002, Julia R. Fielding⁸ in his article, practical MR imaging of pelvic floor weakness, described the H and M lines, PCL line. he concluded that MR images provide relatively easy three-dimensional conceptualization of the pelvic floor and can significantly influence treatment planning.

In 2002, Kavita Singh²¹ evaluated the anatomy and functions of the levator ani in 12 normal women by dynamic magnetic resonance imaging. Conclusion was that the levator ani was not a single muscle but has two functional components that vary in thickness, origin, and function. The ileococcygeus has a mainly supportive function, whereas the puborectalis has a sphincteric function. Gaps in the diaphragmatic portion of the ileococcygeus are a normal finding. Individual components of the levator ani may be prone to different types of childbirth trauma and should therefore be assessed separately when planning rehabilitation.

In 2002, Nandita M. deSouza et al⁵⁶ compared, on high-spatial-resolution magnetic resonance (MR) images, the presence and distribution of the paravaginal fascia in 11 continent women and in those with 10 genuine stress incontinence (GSI) to establish its role in the pathophysiology of GSI. There is a significant association between urethral PFV and continence status. GSI patients have a reduced urethral PFV, and greater than 40% of their urethral length lies below the pubis in the supine position at rest.

In 2003, Jeong Kon et al⁷ reviewed MR images obtained using an endovaginal coil in 63 patients with stress urinary incontinence and in 16 continent women. A high degree of asymmetry of puborectalis muscle was more frequent in the group with stress urinary incontinence than in the continent group. Distorted periurethral ligaments were found in 56% of the patients with stress urinary incontinence versus 13% of the women who were continent; distorted paraurethral ligaments were found in 83% of the patients with stress urinary incontinence versus 19% of the women who were continent; and distorted pubourethral ligaments were found in 54% of the patients with stress urinary incontinence versus 19% of the women who were continent ($p < 0.05$). The group with stress urinary incontinence had a greater vesicourethral angle (148° vs 125°)

and larger retropubic space (7.5 vs 5.1 mm) than did the women who were continent ($p < 0.05$).

In 2003, John O. L. DeLancey³¹, studied the appearance and occurrence of abnormalities in the levator ani muscle seen on magnetic resonance imaging (MRI) in 80 nulliparous women and in 160 women after their first vaginal birth. Abnormalities in the levator ani muscle are present on MRI after a vaginal delivery but are not found in nulliparas.

In 2004, Kuo-Cheng Lien et al¹⁹ evaluated serial magnetic resonance images from a healthy nulliparous 34-year-old woman to quantify pelvic floor muscle stretch induced during the second stage of labor. The largest tissue strain reached a stretch ratio (tissue length under stretch/original tissue length) of 3.26 in medial pubococcygeus muscle, the shortest, most medial and ventral levator ani muscle. Tissue stretch ratios were proportional to fetal head size. The medial pubococcygeus muscles undergo the largest stretch of any levator ani muscles during vaginal birth.

In 2005, Maaike p.Terra et al²⁵ prospectively compared external phased-array MR imaging with endoanal MR imaging in depicting external and internal anal sphincter defects in 30 patients with fecal

incontinence. They concluded that both MR imaging techniques did not significantly differ in the depiction of external ($P > .99$) and internal ($P > .99$) anal sphincter defects. The techniques corresponded in 25 (83%) of 30 patients for the depiction of external anal sphincter defects and in 28 (93%) of 30 patients for the depiction of internal anal sphincter defects.

In 2006, Katarzyna J. Macura,⁵ Rene R. Genadry, and David A. Bluemke described the role of high-resolution MR imaging which allows detailed visualization of the urethral sphincter and supporting ligaments in women and may contribute to the diagnosis and staging of sphincteric incompetence related to intrinsic sphincter deficiency or urethral hypermobility. Both the anatomy and the function of the female urethra can be depicted on MR images.

In 2006, Yvonne Hsu et al²³ conducted a study to determine whether the levator plate is (1) horizontal in women with normal support, (2) different between women with and without prolapse, (3) related to levator hiatus and perineal body descent. They concluded that the measured levator plate angle in women with normal support is 44.3. During Valsalva, women with prolapse have a statistically greater levator plate angle compared to controls. This larger angle showed

moderate correlation with larger levator hiatus length and greater displacement of the perineal body in women with prolapse compared to controls.

ANATOMY OF THE PELVIC FLOOR

The pelvic floor is a complex, integrated, multilayer system that provides active and passive support. The pelvic floor has three layers from superior to inferior:

1. The pelvic fascia
2. Pelvic diaphragm and
3. Urogenital diaphragm,

with their associated supportive structures, urethra, anal sphincter, and vagina in women.

Pelvic Fascia

Pelvic fasciae are delicate structures, most of which are below imaging resolution. The most cephalad layer covers the levator ani muscle and viscera in a continuous sheet. At the uterine level, this layer is called the parametrium; at the vaginal level, it is called the paracolpium. Two dense aggregations of obturator and levator ani fasciae, the arcus tendineus fasciae pelvis and arcus tendineus levator ani, provide important passive lateral support. The arcus tendineus

fasciae pelvis provides lateral anchoring for the anterior vaginal wall where it underlies and supports the urethra, while the arcus tendineus levator ani provides anchoring for the levator ani muscles. The arcus tendineus levator ani can be identified MR images as the origin of a part the levator ani muscle (iliococcygeus muscle) at the internal obturator fascia

Pelvic Diaphragm

The levator ani muscle complex consists of three muscle groups:

- (a) The iliococcygeal muscle, which arises from the junction of the arcus tendineus fascia pelvis and the fascia of the internal obturator muscle;
- (b) The pubococcygeal muscle, which arises from the superior ramus of the pubis; and
- (c) The puborectalis muscle, which arises from the superior and inferior pubic rami. The iliococcygeal and pubococcygeal muscles insert into the lateral parts of the coccyx, whereas the fibers of the puborectalis muscle form a sling around the rectum.

The levator ani is innervated by sacral nerve roots S2 through S4 via the pudendal nerve.

In healthy women at rest, the levator ani muscles are in contraction, thereby keeping the rectum, vagina, and urethra elevated and closed by pressing them anteriorly toward the pubic symphysis. The components of the levator ani muscles are clearly seen on T2-weighted MR images.

Urogenital Diaphragm

The urogenital diaphragm, also called the deep perineal space or perineal membrane, is situated caudal to the pelvic diaphragm and anterior to the anorectum. It is penetrated by the urethra and by the vagina in women. The primary muscle of the urogenital diaphragm is the deep transverse muscle of the perineum, which originates at the inner surface of the ischial ramus and is readily visible at MR imaging .

Urethra

The female urethra is approximately 4.5 cm long, with two-thirds of the urethra above the levator ani (pelvic diaphragm). The proximal one-third of the female infoldings of urothelial tissue with rich

submucosal vascular plexuses, mucosal secretions, and urethral smooth muscle all contribute to passive urethral closure (urethral coaptation, mucosal seal).

The urethral sphincter is composed of involuntary inner smooth muscle that is continuous with the bladder, as well as the voluntary external sphincter (rhabdosphincter), which is composed of striated muscle. The external sphincter contributes mainly to resting pressure by means of slow-twitch muscle fibers. The urogenital diaphragm muscle (deep transverse muscle of the perineum) predominantly contributes to voluntary and reflex muscle contraction.

Urethral and Bladder Neck Supporting Structures

Fascial and ligamentous support of the urethra and the bladder neck is vital to preserve urinary continence.

Vesicopelvic, urethropelvic, and pubourethral ligaments and fascia give anterior and lateral support to the bladder neck and urethra by means of attachment to the pubic bone and arcus tendineus fasciae pelvis. The urethropelvic ligaments can be easily identified with high-resolution MR imaging in almost all individuals. Other ligaments between the urethra and pubic arch (pubourethral ligament) and between

the bladder and pubic arch (vesicopelvic ligament) can be identified in some individuals.

Vagina

The vaginal wall is composed of smooth muscle and connective tissue (collagen and elastin). The anterior wall is bridged bilaterally between the arcus tendineus fasciae pelvis. This "hammock" of vaginal tissue lies beneath the urethra and may be a vital component of urinary continence. The urethra is compressed against this tissue when abdominal pressure is increased as during coughing.

Perineal Body

Directly anterior to the anal sphincter is the perineal body (central tendon of the perineum). Many structures insert fibers into the perineal body, including the external anal sphincter, the deep and superficial transverse muscles of the perineum (urogenital diaphragm), and the bulbocavernosus and puborectalis (pubococcygeus) muscles. The superficial transverse muscle of the perineum spans the dorsal edge of the urogenital diaphragm and elevates the perineal body.

Anal Sphincter

The anal canal sphincter contains muscular and neurovascular components and is surrounded by the fat-containing ischioanal space. The mechanism of anal continence is similar to that of urinary control, with the anal lining and its underlying vascular spaces, the anal cushions, playing a major role in sealing the anal canal. The anal sphincters form two cylindric layers between which lies the longitudinal muscle. The intersphincteric space is a plane, composed of fat, usually located between the longitudinal muscle and external sphincter.

The internal sphincter forms the innermost muscular layer and is the terminal condensation of the circular rectal smooth muscle. The internal sphincter extends from the anorectal junction to approximately 1–1½ cm below the dentate line. It is composed of smooth muscle fibers with autonomous innervation from sympathetic presacral nerves.

The external sphincter is the outermost muscle of the distal anal canal and is composed of several parallel bundles. It is a circular structure and is shorter anteriorly in women, approximately 1½ cm. The external sphincter extends approximately 1 cm beyond the internal sphincter. The deep part of the external sphincter is fused with or

intimately related to the puborectalis muscle. Anteriorly, it is closely related to the superficial transverse muscle of the perineum and the perineal body . Posteriorly, the muscle is continuous with the anococcygeal ligament . All sphincter muscles are readily seen at endoanal MR imaging. The muscle is under voluntary control and is innervated by the pudendal nerves (S2 through S4). The puborectalis muscle has separate innervation from S3 and S4.

Compartments

The female pelvic floor can be divided into three compartments:

- 1) Anterior containing the bladder and urethra,
- 2) The middle containing the vagina, and
- 3) The posterior containing the rectum.

The endopelvic fascia and the levator ani muscle support each of these compartments.

IMAGING IN PROLAPSE AND STRESS INCONTINENCE

Urinary Functional Tests

Urodynamic tests are the most important functional tests in urinary dysfunction. Flow rate measurement is an index of the volume voided in a unit time, expressed as millimeters per second. Detrusor underactivity, instability, and outlet obstruction produce abnormal flow patterns. Cystometrography (CMG) is used to measure the relationship between bladder pressure and volume for evaluation of the detrusor functions of compliance and contractility. Urethral pressure profiles are records of intraurethral pressure and can demonstrate pressure equalization between the bladder and urethra at the high-pressure area.

Video urodynamics (VUDO), also called video cystourethrography is a combination of CMG and voiding cystourethrography that integrates pressure and imaging studies. Urodynamic measurements are integrated with fluoroscopic findings.

Manometry

Manometry is used to determine rectal and anal pressures. Resting pressure is reduced in incontinence due to abnormality of the internal sphincter. In contrast, squeeze pressure, the incremental increase over resting pressure elicited when the patient is asked to voluntarily contract his or her anus, is reduced when incontinence is due to external sphincter tears. A dual sphincter abnormality is suggested when both resting and squeeze pressures are abnormal.

Pudendal Nerve Latency

Pudendal nerve terminal motor latency can be determined on the basis of the time needed for a digitally delivered pudendal nerve stimulus to elicit anal contraction.

US of the Bladder, Bladder Base, Urethrovesical Junction, and Urethra

Bladder US to determine the residual volume is frequently combined with flow rate estimation. An increased wall thickness and increased flow at the fundus of the bladder during color Doppler US may indicate detrusor instability. US evaluation of urethrovesical

junction mobility and bladder base morphology was initially performed by using transabdominal techniques and later by using endorectal, endovaginal, and perineal approaches.

Voiding Cystourethrography

Voiding cystourethrography (VCUG) is performed primarily to detect a cystocele and evaluate urethrovesical junction mobility. When combined with evacuation proctography, VCUG is termed cystoproctography. Lateral fluoroscopy at rest, during coughing, and during voiding helps differentiate between bladder neck descent or urethrovesical junction hypermobility, defined by bladder base descent below the inferior margin of the pubic symphysis.

Endoanal US

The external sphincter, intersphincteric plane, and longitudinal muscle are each relatively heterogeneous and visible when the latest generation of high-frequency (10-MHz) transducers are used.

MRI

Dynamic ultrafast MR imaging using the single-shot fast spin-echo sequence allows dynamic evaluation of the pelvic compartments at

maximal strain. Heavily T2-weighted images give excellent tissue differentiation with no need for contrast medium. Advantages of MR imaging include lack of ionizing radiation, depiction of the soft tissues of the pelvic floor, and multiplanar imaging capability. Dynamic imaging is usually necessary to demonstrate pelvic organ prolapse, which may be obvious when abdominal pressure is increased. Treatment is more likely to be successful if a survey of the entire pelvis is performed prior to therapy.

Evacuation Proctography

Evacuation proctography is a simple radiologic technique that involves imaging of rectal voiding of a barium paste enema.. Constipation is the main indication for performance of evacuation proctography. An obtuse anorectal angle may help identify patients likely to benefit from postanal repair if the anal sphincters appear normal at US. It has been argued, however, that involuntary loss of barium alone may be sufficient for diagnosis.

MATERIALS AND METHODS

The study was performed on a 1.5 Tesla super conductive whole body MRI scanner MAGNETOM VISION (SIEMENS MAGNETIC VISION).

During the study the patient is placed on the strong homogenous magnetic field. The hydrogen nuclei, protons, distributed through the entire body tissue generate signals when stimulated by a radio frequency pulse. These signals are processed into images by a computer.

Study Place

Barnard Institute Of Radiology, Madras Medical College.

Study Period

February 2006 To August 2007

Patient Evaluation And Selection

Inclusion:

- 1) Patients with stress incontinence
- 2) Pelvic Prolapse
- 3) Recurrence after surgery

Exclusion:

- 1) Cardiac Pacemaker
- 2) Cochlear implants
- 3) Claustrophobia

The mainstay of diagnosis of symptomatic pelvic floor damage is the physical examination. The physician notes the location of several anatomic landmarks when the patient is at rest and at pelvic strain and then scores the degree of pelvic descent. Physical examination findings are correlated with patient symptoms to determine the operation to be performed.

A cystocele alone is treated with a retropubic (Burch) colposuspension, which entails suspending the lateral aspects of the bladder from the pelvic sidewalls. When the fascia is detached from the tendinous arch, a paravaginal fascial repair is added. Uterine prolapse is usually treated with a hysterectomy and uterosacral suspension, some times with the addition of mesh support. For an enterocele, the rectovaginal fascia is reapproximated. Repair of a rectocele entails a posterior colporrhaphy.

The vast majority of patients with incontinence and minimal pelvic floor weakness can be treated based on physical examination and basic urodynamic findings. These patients do not need to undergo MR imaging. Also, many continent postpartum women will have some degree of pelvic floor weakness. Imaging these asymptomatic women is of no value.

In those patients with symptoms of multicompartiment involvement for whom a complex repair is planned and in those women who have undergone previous repairs, MR imaging can be very useful as a preoperative planning tool. Despite surgeons' best efforts, symptoms recur in 10%–30% of patients, and the cause of the problems often involves compartments of the pelvic floor that were not repaired initially. Preoperative MR imaging of the pelvic floor can help determine which compartments of the pelvis are damaged and can help identify specific muscle defects.

Patient Preparation

- 1) Partially filled bladder
- 2) No fasting
- 3) Coach the patient to do valsalva

Coils

- 1) Torso phased array coil
- 2) Body coil

Sequence Parameters

Imaging with the patient in the supine position has been shown to be perfectly satisfactory for evaluating symptomatic pelvic floor weakness, despite the fact that defects are most easily identified when patients are upright. The MR imaging protocol requires no oral or intravenous contrast agents, and the examination can be completed in 15 minutes.

The patient positioned on the MR imager table with a multicoil array wrapped low around the pelvis. Scout images are obtained to identify a midline sagittal section that shows the pubic symphysis, urethra, vagina, rectum, and coccyx. Next, 5 mm-thick sagittal images of the midline are obtained with a rapid half-Fourier T2-weighted imaging sequence, half-acquisition single-shot turbo spin echo, HASTE, and a 30-cm field of view. These images are obtained while the patient is at rest and during the Valsalva maneuver. Many patients require coaching to achieve maximal pelvic strain. Next, 5-mm-thick axial T2-weighted

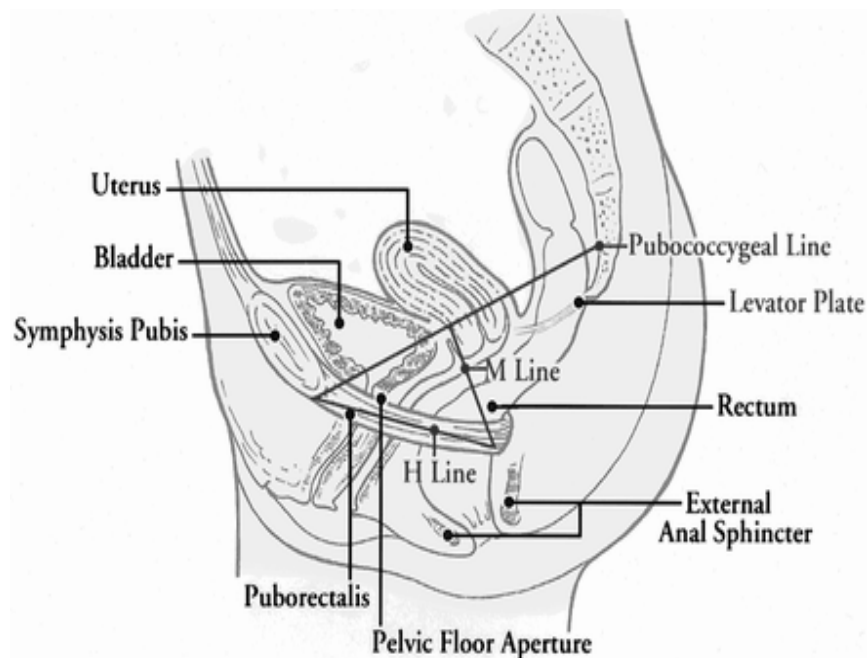
images of the pelvic floor centered on the puborectal muscle are obtained with a 20-cm field of view and a standard high-resolution sequence such as fast spin echo. Coronal images are obtained. The complete protocol is summarized.

Pulse sequence	Plane	TR/TE (msec)	FOV (cm)	Slice thickness (mm)	Flip angle	Matrix frequency* phase	NEX
Scout	Sagittal	15/5	350-400	10	1*	160*256	-
HASTE	Sagittal	4.4/90	300	5	180*	128*256	1
T2 FSE	Axial	5000/130	200-250	5	180*	270*256	2
T2 FSE	Coronal	5000/130	200-250	5	180*	270*256	2

Dynamic MR was done using Tru Fisp sequence for some patients.

INTERPRETATION

The radiologist should begin the interpretation of the sagittal MR images by drawing the pubococcygeal line (PCL) as in figure.



PCL -This line extends from the inferior border of the pubic symphysis to the last joint of the coccyx and represents the level of the pelvic floor. The distance from the pubococcygeal line to the bladder neck, cervix, and anorectal junction should be measured on images obtained when the patient was at rest and at maximal pelvic strain. The bladder neck is easily identified in all women because of the high T2 signal of urine. The cervix and anorectal junction can be harder to identify; however, a reasonable estimate of their locations is usually

possible. In healthy women, there is minimal movement of the pelvic organs, even with maximal strain. In a symptomatic patient, organ descent of greater than 1 cm below the PCL line indicates pelvic floor laxity, and organ descent greater than 2 cm is often indicative of the need for surgical intervention

H line -anteroposterior width of the levator hiatus and is drawn from the inferior aspect of the pubic symphysis to the posterior wall of the rectum at the level of the anorectal junction.

M line - vertical descent of the levator hiatus and is drawn as a perpendicular line dropped from the pubococcygeal line to the most posterior aspect of the H line. Both of these lines become elongated during the Valsalva maneuver in the patient with pelvic floor laxity.

The posterior urethrovesical angle is extremely variable among continent and incontinent women and is of little value in the identification of significant pelvic floor weakness.

Angle of the levator plate with the pubococcygeal line is measured. In healthy women, the levator plate will parallel the pubococcygeal line at rest and during pelvic strain. Increased caudal inclination is an indicator of loss of posterior muscular support.

Thinning and tears of the puborectal and iliococcygeal muscles should be examined on the axial and coronal images, Paravaginal fascial tears can be inferred from posterior displacement of the vaginal fornix . On axial images, the anterior external urethral sphincter and thin fascial condensations that support the upper portion of the urethra (sometimes called the lateral pubovesical ligaments) can also be seen.

NORMAL APPEARANCE OF THE PELVIC FLOOR

In healthy, continent women, even with maximal downward pelvic strain, MR images demonstrate minimal descent of the pelvic organs.

PCL LINE -The bladder neck, vaginal fornices, and anorectal junction all remain at or above the pubococcygeal line. On sagittal images obtained during pelvic strain, the urethra should maintain its normal, slightly anterior orientation to the bladder base.

H line should measure a maximum of 6 cm

M line should measure a maximum of 2 cm

On axial images, the entirety of the levator sling should be of similar thickness and homogeneous low signal intensity.

On coronal images, the iliococcygeal muscle should be intact and upwardly convex. As women age, some thinning of the levator ani muscle occurs normally; however, no tears should be identified.

The vagina should have an H-shaped configuration, which indicates adequate lateral fascial support.

MR FINDINGS OF PELVIC PROLAPSE

Cystocele and Stress Incontinence

Criteria that have been proposed for diagnosis of cystocele at imaging include

- 1) Bladder below the pubic symphysis.
- 2) Bladder more than 1 cm below the pubococcygeal line

Stretching or tearing of the pubocervical fascia and levator ani muscle allows the posterior aspect of the bladder to descend below the pubococcygeal line and to bulge into the anterior vaginal wall. MR images obtained during pelvic strain show the change in position of the bladder and the resulting cystocele. The H line should exceed 6 cm and the M line should exceed 2 cm. Fascial defects may be midline, lateral, or a combination of the two.

For uncomplicated stress incontinence, a retropubic urethropexy is the surgical procedure of choice. Loss of intrinsic urethral sphincter integrity and anterior fascial supports of the bladder neck leads to rotation of the bladder and urethra anteriorly and superiorly. In severe cases, the apposition of the urethra and anterior bladder wall will mask

symptoms of stress incontinence. It is important to identify this urethral hypermobility because it usually requires a pubovaginal sling procedure for adequate repair.

Uterine or Vaginal Vault Prolapse

Criteria that have been used in the literature to define cervical and vaginal vault prolapse include cervix or vaginal vault below the pubococcygeal line.

Muscle damage and stretching or tearing of the uterosacral ligaments allows descent of the vaginal fornices and uterus below the pubococcygeal line. In women with such damage on sagittal MR images obtained during pelvic strain, the H and M lines are elongated. On axial images, the cervix is often at the level of the pubic symphysis and there is loss of the normal H shape of the vagina, often with posterior displacement of the fornix on the affected side. In severe cases, the puborectal muscle may be avulsed from its insertion on the pubic rami. On coronal images, there is significant posterior weakness.

Rectocele, Sigmoidocele and Enterocele

On sagittal MR images obtained during pelvic strain, rectoceles usually appear as an anterior bulge in the contour of the rectum. Typically, a line drawn through the anterior wall of the anal canal is extended upward, and a rectal bulge of greater than 2–3 cm anterior to this line is described as a rectocele.

Descent of small bowel loops more than 2 cm into the rectovaginal space indicates tearing of the rectovaginal fascia. On axial images, loops of sigmoid or small bowel can be seen insinuated between the rectum and vagina.

Pelvic Floor dysfunction

Patients with pelvic floor dysfunction may have abnormalities of the perineal body and levator ani musculature.

Diffuse bulging of the levator ani muscle occurs in patients with perineal descent, resulting in an increase in the area of the pelvic hiatus. This is the area enclosed by the levator ani muscle at the level of the pubic symphysis.

Perineal descent can be quantified by measuring the descent of the anorectal junction relative to the pubococcygeal line and is considered abnormal when the excursion is greater than 2 cm. Descent of the perineal body can also be measured.

The width of the levator hiatus, measured as the H line from the pubis to the posterior anal canal, is greater (more than 6 cms) in patients with prolapse than in those without prolapse.

Descent of the levator plate relative to the pubococcygeal line (the M line) is also greater than (>2cms) in patients with prolapse.

Caudal angulation of the levator plate is present in women with prolapse such that a line drawn on a sagittal image from the levator plate does not cross the pubic bone.

Asymmetry in levator thickness and fatty degeneration is seen in patients with urinary incontinence.

The inadequate coaptation of the urethra (the so-called intrinsic sphincter deficiency) and the downward displacement of the urethra due to weak urethra-supporting structures (the so-called urethral hypermobility) can result in stress incontinence

RESULTS AND OBSERVATIONS

The study was conducted on 50 incontinent women and 15 normal continent women and the following observations were observed.

Among the 50 incontinent women, H line was found to be more than 6cms (levator hiatus widening) in 42 patients and in 1 patient among the 15 normal controls.

TABLE - 1

H - LINE

H Line (cms)	Incontinent	Normal
≥ 6	42	1
< 6	8	14

M Line

M Line signifies vertical descent of levator hiatus.

Among the 50 incontinent patients M Line was greater than 2 cm in 44 women.

TABLE - 2

M - LINE

M Line (cm)	Incontinent	Normal
> 2	44	0
< 2	6	15

Levator Plate Angulation

Increased caudal inclination indicates loss of posterior muscular support. It was seen in 49 among 50 symptomatic patients.

TABLE - 3

LEVATOR PLATE ANGULATION

LP Angle	Incontinent	Normal
Increased	49	0
Normal	1	15

Normal Shape Of Vagina

H shape vagina was lost in 46 patients among the 50 incontinent women. It was also lost in 2 of the 15 normal controls.

TABLE - 4

NORMAL SHAPE OF VAGINA

H Shape Vagina	Incontinent	Normal
Lost	46	2
Normal	4	13

Puborectalis Asymmetry

Asymmetry between the puborectalis was found in 20 symptomatic patients and in one normal patient.

TABLE - 5

PUBORECTALIS ASYMMETRY

PR Asymmetry	Incontinent	Normal
Positive	20	1
Negative	30	14

Assessment Of Pelvic Floor Laxity

TABLE - 6

ASSESSMENT OF PELVIC FLOOR LAXITY

	Sensitivity (%)	Specificity (%)	PPV (%)
H Line	84	93	98
M Line	88	100	100
LP A	98	100	100
PRA	40	93	95
H Vagina Lost	92	87	96

H Line indicating widening of the levator hiatus was found in 42 patients among 50 and two normal controls. Thus the sensitivity of H Line is 84% and specificity is 93%.

Specificity of M Line indicating descent of levator hiatus is 100%. Thus the positive predictive value (PPV) of all the above parameters is above 95%.

Urethral Hypermobility

Urethral hypermobility which is one of the causes of stress incontinence was found in 20 patients among 50.

TABLE - 7

URETHRAL HYPERMOBILITY

Urethral Hypermobility	No. Of Patients	Percentage
Positive	20	40%

Grading Of Cystocele

This table shows the number of patients under each grade of cystocele in the symptomatic study group. The grading was done with regard to the descent of the base of the bladder below the pubococcygeal line (PCL).

TABLE - 8

GRADING OF CYSTOCELE

GRADE	No. Of Patients	Percentage (%)
0 (Above PCL)	5	10
1 (0 – 2 cm Below PCL)	4	8
2 (2 – 4 cm Below PCL)	21	42
3 (4 – 6 cm Below PCL)	20	40

Grading Of Uterine Prolapse

This table shows the number of patients under each grade of Uterine prolapse in the symptomatic study group excluding those with recurrence. The grading was done with regard to the descent of the organ below the pubococcygeal line (PCL).

TABLE- 9

GRADING OF UTERINE PROLAPSE

GRADE	No. Of Patients	Percentage
0 (Above PCL)	8	19
1 (0 – 2 cm Below PCL)	16	38
2 (2 – 4 cm Below PCL)	8	19
3 (4 – 6 cm Below PCL)	10	24

Recurrence

Among the 8 patients with recurrence all had cystoceles, 4 had enterocele and 4 had vault prolapse.

TABLE - 10
RECURRENCE

	No. Of Patients	Percentage (%)
Cystocele	8	100
Enterocele	4	50
Vault Prolapse	4	50

DISCUSSION

MRI can be used in diagnosing pelvic floor dysfunction without ionizing radiation and administration of contrast material.

Total of 65 patients including 15 normal controls formed the study group. Most of the patients belonged to 4th and 5th decade. The commonest complaint among them was stress incontinence.

MRI can be used as a single imaging modality with many applications.

For Diagnosis

MRI provides outstanding anatomic detail of pelvic floor including cystocele, uterine prolapse, enterocele and rectocele.

The 50 symptomatic women included those with recurrence, which was in 8 patients. Among the 42 patients with exclusion of recurrence, cystocele was found in 38 patients, associated uterine prolapse in 32 patients and rectocele in 3 patients.

MRI is sensitive in diagnosing early uterine descent. Gousse and associates reported sensitivity of 83%, specificity of 100% and

predictive value of 100% when comparing MRI with intra operative findings.

Grading Of Organ Prolapse

Organ prolapse can be graded depending on the descent of the organ below the PCL Line. Grading is important for the mode of treatment as grade 1 cystocele can be observed or repaired with bladder neck suspension procedures. Where as grade 2 and 4 are repaired trans abdominally or trans vaginally with other procedures.

Among the 50 patients, 4 patients had grade 1 cystocele which is around 8%, 21 patients in grade 2 and 20 patients with grade 3.

Among the 42 patients with out recurrence, 16 patients had grade 1 uterine prolapse which is 38%, 8 patients had grade 2 (19%) and 10 patients had grade 3 (24%).

Assessment Of Pelvic Floor Laxity

Pelvic floor laxity was greater in stress incontinent group than in negative controls as shown by dynamic MRI.

	Sensitivity %	Specificity %	PPV %
H Line	84	93	98
M Line	88	100	100
LP A	98	100	100
PRA	40	93	95
H Vagina Lost	92	87	96

H Line indicating widening of the levator hiatus was found in 42 patients among 50 and two normal controls. Thus the sensitivity of H Line is 84% and specificity is 93%.

Specificity of M Line indicating descent of levator hiatus is 100%. Thus the positive predictive value of all the above parameters is above 95%.

Cause Of Stress Incontinence

Urinary stress incontinence has 2 main causes

- 1) Urethral hypermobility
- 2) Intrinsic sphincter deficiency

Among the 50 patients Urethral hypermobility was found in 16 patients and thus the type of surgery can be modified based on the presence of urethral hypermobility.

Recurrence / Multi compartmental Prolapse

Among the 8 patients with recurrence cystocele was found in all, enterocele in 4 patients and vault prolapse in 4 patients which emphasizes the role of pre operative MRI to avoid recurrence.

As a result of vaginal crowding an enterocele is often missed on physical examination when it is accompanied by other prolapse. In our study 4 patients had enterocele as diagnosed by dynamic MRI but wasn't found by clinical examination.

Gousse and colleagues compared clinical findings and MRI with intra operative findings and found sensitivity of 87%, specificity of 80% and positive predictive value of 91% with MRI when compared to physical examination. Lienemann and associates showed that MRI had much greater sensitivity in detection of enteroceles compared with physical examination.

Evaluation Of Concomitant Pathology

MRI has the advantage of diagnosing associated pathologies like fibroid, nabothian cyst, etc. Lumbar disc herniations can also be diagnosed which could be the real cause of backache in some prolapse patients.

CONCLUSION

Dynamic ultrafast MRI using single shot fast spin echo allows evaluation of pelvic compartments at maximal strain. Heavily weighted T2 images give excellent tissue differentiation with no need for contrast medium.

The study showed that pelvic floor laxity was more common in patients with stress incontinence.

Pelvic floor supports the bladder, uterus, rectum and small bowel. Effects of pelvic floor weakness may not be confined to one compartment. Failure to identify all defects of pelvic floor integrity may lead to incomplete surgical repair with either persistence or recurrence. This emphasizes the importance of pre operative MR imaging to plan appropriate surgery.

Dynamic MR evaluation of urethral sphincter during strain along with functional and morphological assessment assist in classification of incontinent patients into hypermobility and intrinsic sphincter deficiency categories. Thus it contributes to guide the choice of therapy. Kinematic MR also helps in visualization of dynamic changes under strain.

MRI plays a major role especially in multicompartmental prolapse where clinical examination may miss enteroceles due to vaginal crowding. MRI is more sensitive than physical examination in diagnosing enteroceles.

In patients with recurrence, MR scores over clinical examination in diagnosing organ of prolapse as well as enterocele. It can also detect tear of sphincter , muscle and the ligament.

Preoperative MR is useful when site specific repair is planned which is becoming popular now and many institutions have started operating based on site specific pathology.

To diagnose levator hiatus widening ,as indicated in MR as Hline > 6 cm so that prophylactic levatoplasty can be done.This can prevent development of future prolapse .

Can simultaneously evaluate uterine pathologies like fibroids, adenomyosis, nabothian cysts etc. Can also diagnose associated disc herniations which might be the real cause of back pain.

MRI serves as a single important investigation which can help in the diagnosis of organ prolapse, grading, assessment of pelvic floor weakness, cause of stress incontinence and diagnosis of other associated pelvic pathologies.

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PROFORMA

Name : Address:

Age/Sex :

Clinical History:

Stress Incontinence

Back Pain

Urge Incontinence

Fecal Incontinence

Voiding Difficulty

Past History Of Surgery:

Obstetric & Menstrual History:

Parity

Mode Of Delivery

Place of Delivery

Number Of Abortions

Menstrual History

Menopause

Clinical Examination:

Vitals: Pulse Rate

Temperature

Blood Pressure

Respiratory Rate

P/V Findings:

Speculum Examination:

Investigations:

Hb%	TC
DC	ESR
Ultrasound Pelvis	VCUG
Urodynamic Study	Cystoscopy

MRI Findings:

No.	Parameters	At Rest	Valsalva
1	Bladder base below PCL Line.		
2	Uterus below PCL Line		
3	Anterior bulge of rectal wall into cul-de-sac		
4	H Line		
5	M Line		
6	Levator plate inclination		
7	Asymmetry of Puborectalis		
8	Loss of H Shape of vagina		
9	Orientation of urethra on straining		

GLOSSARY

SI - STRESS INCONTINENCE

RI - RECTAL INCONTINENCE

BL - BLADDER

RP - RECTAL PROLAPSE

Cx - CERVIX

EC - ENTEROCELE

PCL - PUBOCOCCYGEAL LINE

VAG - VAGINA

PRA - PUBORECTALIS ASYMMETRY

LPA - LEVATOR PLATE ANGULATION

UH - URETHRAL HYPERMOBILITY